Data Processing in University Administration

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This paper describes the initial stages of mechanization of student records which is being carried out in the University of Leeds on a Pegasus computer. It illustrates techniques employed in handling a large mass of data, relating to University students, which has to be prepared and processed extremely rapidly.

Introduction

The University of Leeds has expanded rapidly since the war, and student numbers have risen from about 2,000 in 1946 to over 4,500 in 1959, and it is expected that numbers will increase further. In December 1957 the University installed a Ferranti Pegasus computer, primarily as a tool for scientific research. In view of increasing student numbers, members of the University administrative staff have since then taken a lively interest in the possibilities of using the computer for data processing. In the autumn of 1958 it was known that the computer would shortly be fitted with magnetic-tape equipment which would facilitate large-scale processing and the storage of records, and it was therefore decided to consider possible areas of mechanization with a view to making a long-term plan for use of the computer, and to choose a suitable task on which to commence work.

A useful starting point appeared to be the University's system of student records. The procedures connected with the students are concerned principally with the selection of applicants for admission, the registration of students at the beginning of each academic year, the payment of fees, lodging arrangements, examinations, reports to grant-awarding authorities and appointment after graduation; each of these procedures involves the compilation and maintenance of records and the extraction of statistics required by University committees and outside bodies. Some of these procedures involve all the teaching departments of the University, as well as a number of administrative offices such as the Registrar's, which deals with admissions, registration, examinations and reports; the Bursar's, which receives tuition and lodging fees and acts as agent for the payment of grants; the lodgings offices; the Appointments Board office; the office of the Warden of Overseas Students; and offices of Deans and Tutors in the various Faculties who keep records of students' academic progress. The information required by these offices and the teaching departments is sufficiently homogeneous, however, to make it possible to treat student records virtually as a single unit for the purpose of mechanization, and this was clearly the field of operation in which the computer was most likely to be effective.

Initial Planning

It would appear, logically, that the student records would most economically be compiled and set up once for all on magnetic tape when the information is first received, that is, on receipt of an application for admission. The information obtained on admission, however, includes much that is used then but not later (e.g. whether Leeds is the University of the student's first preference) and does not include some information which is needed later, and which, indeed, cannot be collected until the student has actually registered at the beginning of the academic year with a department of the University (e.g. subsidiary subjects). Furthermore, the number of students applying for admission in recent years has been four or five times the number finally registered, due in part to pressure for places and in part to application by students to more than one University. The use of information provided on the application form for admission as the basis of student records would thus be wasteful and inefficient, all the more so as the definite acceptance of an applicant in August does not necessarily guarantee his registering as a student in October. It was therefore decided that the initial attack should be on the processing of data collected at registration; positive arguments supporting the decision were:

(*a*) this data requires more frequent manipulation than any other records compiled in the University administration;

(*b*) the lists and figures needed must often be produced very quickly; and

(*c*) the bulk of this work must be done when the clerical staff is hard pressed.

The Registration Procedure before Mechanization

Up to the year 1958–59 all students at the University of Leeds registered annually in October on the first three days of term. Each student attended a function known as the "bazaar" in the Central Court of the University at which representatives of the teaching departments and the administrative offices were present. On arrival he was asked to fill in a form with his name, date of birth, home address, address during term, sources of financial assistance, and other relevant information. He then took the form to the representative of the department in which he was studying, who wrote on it the main scheme of study which the student was following and the subsidiary courses he was taking. Next the student went to the representatives of the departments giving each of the subsidiary courses, and had his form countersigned by them. He could then pay his fees and hand in his form to complete his registration.

Owing to the great increase in numbers in the University this procedure was becoming cumbersome, and the hall congested.

After registration, the forms were arranged in alphabetical order and the information on them was copied manually into a register, from which statistics required by the University Council and Senate and by the University Grants Committee were extracted, a laborious and lengthy process. The forms were then used as the basis for other statistical schedules and lists, including a printed list of students which was received by the teaching departments and the administrative offices in December or January, long before which time the departments had had to draw up their own lists of students. The list provided by the Registrar therefore served chiefly as a check on records already compiled.

The chief weakness of the old system was that the teaching departments did not know before October exactly how many students to expect and could not, therefore, arrange time-tables and accommodation except by guesswork. The practice had developed, between a number of departments, of exchanging during the summer vacation lists of students who had passed June examinations and who had thereupon decided on their next year's course. What departments needed, however, were full provisional lists, in September, of students likely to come to them in the following term (such lists would need to show other subjects studied by each student), and complete lists *immediately* after registration, before lecture-courses began. This could not possibly be done manually.

Administrative Changes

The time when loss of efficiency under the old system made administrative changes imperative fortunately happened to coincide with the coming into operation of the magnetic-tape equipment, and it was therefore possible to review the registration system from first principles with the use of the computer in mind. The first step was to bring forward the registration of returning students who had passed June examinations to the period immediately after the results of those examinations became known; the teaching departments were asked to see these students during the last week or two of the summer term to authorize the subjects of their succeeding year's course. As these students, about a half of the total student body, were required in the following October only to complete administrative formalities such as the payment of fees, the "bazaar" registration was restricted to new students and those who had had to repeat examinations in September, so relieving congestion considerably. The "June registration" system also made it possible for the teaching departments to be provided with lists of students during the vacation, enabling them to plan their work more reliably. Most important of all from the computing point of view, it spread the task of data preparation which would otherwise have been almost impossibly concentrated into a few days in early October.

Two possible methods of registering students in a University are by entering data on a single card which is brought up to date periodically, or by renewing the complete record each year. Most of the required data about a student is subject to change, so the economy of the single-card system is offset by the disadvantage of having to make numerous amendments. It is easier to compile the magnetic-tape records used by the computer afresh each year than to amend existing records. A single-card system would, moreover, necessitate evolving for the administrative offices a clear method of recording which amendments had been entered into the machine and which had not. Fortunately, the University of Leeds had long since used an annual form system of registration, and this undoubtedly assisted mechanization.

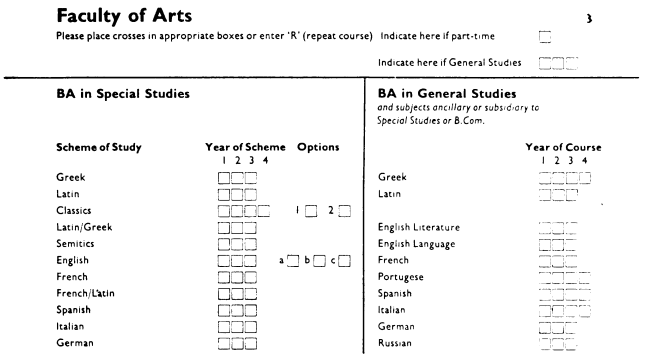
The Registration Form

The opportunity of a general overhaul was taken to modify the registration form itself. Under the old system the student wrote on the form his name, and personal particulars, including home and university addresses, and the source of any financial assistance he received. His department then wrote in and authorized the courses he was taking. The weakness of this method was that it threw on to the staff of the administrative offices a good deal of interpretation of this data (including, occasionally, deciphering the calligraphy of the authorizing departments). For example, one statistical schedule requires the analysis of full-time students, men and women, according to whether their home address is within thirty miles of the University, elsewhere in the United Kingdom, in the Commonwealth, or elsewhere abroad. This calls for some knowledge of geography—and politics. Frequently courses were entered ambiguously and the symbols used could only be interpreted by experienced clerks.

It was decided, therefore, to remodel the registration form in such a way that the students would provide information ready for direct input to the machine. The remodelled form consists of four pages, the first two to be completed by the student, the last two devoted to course entries by the teaching departments. In order to avoid duplication of forms the student's name is typed by the Registrar's staff at the top of page one. When the student receives his form he fills in details of date of birth, sex (not always evident from Christian name), and nationality. Addresses (home and University) are not entered into the machine, but each student is asked to write in a three-figure code indicating the area of his home address from a list on the second page of the form, and to place a cross in one of three boxes to indicate whether he is living at home during University terms, in lodgings, or in a Hall of Residence.

On the last two pages of the form are printed the names of courses in the University, and beside each one three or four boxes, one for each year of study over which the course extends. The teaching departments indicate the course a student is taking by placing a cross in the box for the appropriate year of that course. In

order to keep the form to a manageable size a different form is provided for each Faculty, each form containing all the schemes of study and subsidiary courses which can be taken by students in that Faculty, and printed on different coloured paper. This method ensures that departments mark courses unambiguously. By way of illustration, a part of the form for the Faculty of Arts is shown in Fig. 1.


Faculty of Arts 3

Please place crosses in appropriate boxes or enter 'R' (repeat course) Indicate here if part-time ☐

Indicate here if General Studies ☐☐

BA in Special Studies

Scheme of Study	Year of Scheme 1 2 3 4	Options
Greek	☐☐☐	
Latin	☐☐☐	
Classics	☐☐☐☐	1 ☐ 2 ☐
Latin/Greek	☐☐☐	
Semitics	☐☐☐	
English	☐☐☐	a ☐ b ☐ c ☐
French	☐☐☐	
French/Latin	☐☐☐	
Spanish	☐☐☐	
Italian	☐☐☐	
German	☐☐☐	

BA in General Studies

and subjects ancillary or subsidiary to Special Studies or B.Com.

	Year of Course 1 2 3 4
Greek	☐☐☐☐
Latin	☐☐☐
English Literature	☐☐☐
English Language	☐☐☐
French	☐☐☐
Portugese	☐☐☐
Spanish	☐☐☐
Italian	☐☐☐
German	☐☐☐
Russian	☐☐☐

Fig. 1.—Part of a Student Registration form for the Faculty of Arts.

Coding of Information

In order to make it possible for each student's record to occupy not more than one line of printing in the lists to be produced by the computer, it was necessary to code the course data. Codes of a sort had long been in use for the purpose of the Registrar's list of students, but these codes were not suitable for a teleprinter, and it was decided to approach the coding from first principles. The codes chosen generally consist of two or three letters and one figure. The first two letters designate the department of study, the third letter is used for those departments giving more than one type of course and indicates which course within that department is intended, and the final figure or letter refers to the year of study to which the course is normally appropriate. Thus a student taking second year French is coded FR2, and a student taking the third year of the Diploma course in Textile Industries is coded TID3. Similar codes are used for subsidiary courses—a course in Mathematics taken by Technologists is coded MMT1 and the general course in Physical Chemistry is coded CHGP. The codes were selected so that they could as far as possible use existing symbols (the courses referred to above in Mathematics and Chemistry are generally known as "T1" and "Gp") and be recognizable by members of staff in all departments, especially in those faculties such as Arts, where it was not customary to describe courses by codes. The system of codes evolved is claimed to be reasonably intelligible, and does not require translation on input to and output from the computer. The computer program has been made independent of the exact details of the codes used so that, as new courses are introduced in the University curriculum, they can readily be allocated a new code without any change in the program being necessary.

Information on the registration form, other than the courses a student is taking, is so arranged that it can be coded simply if further coding is needed at all.

Preparation of Data for Input to the Computer

One of the chief considerations in simplifying the presentation of data was the need for the greatest possible speed in entering a large amount of information into the machine in the period immediately after the start of registration on the first day of term. The data from 2,000 to 2,500 forms must be coded and prepared for input in a period of four to five days: if it takes longer, the lists produced on output fail to serve their purpose in the teaching departments. Moreover, this same period is one during which the staffs of the administrative offices are extremely busy, and it is therefore necessary to use typists from an agency who have no knowledge of the terminology of University courses. Coding was therefore carried out this year (1959) by using a template which covered all parts of the registration form except the boxes in which crosses indicated the information required; the code was written on the template and only needed to be read off against the crosses. It was thus possible for coding and the preparation of input tapes to be carried out as one job.

Input to the Pegasus computer is at present by means of paper tape and it is necessary to punch all data on to paper tape before it can be read into the computer. When each form was being punched, the typist placed the template over it, and punched the correct code written on the template beside the box with a cross in it. In future years, once the staff of the University are used to the codes, it is intended to have them printed on the registration form. A student will then be entered for a course by placing a ring round the appropriate code, a method in common use in the market-research field. This should speed up the punching considerably, since the typists will have no templates to hamper them in this part of the work.

Organizing the Punching

The punching was carried out on standard Creed keyboard perforators of the type which do not produce a printed copy. The keyboards are set up with Pegasus code symbols, and contain extra keys for figures, with an interlock to prevent mispunching by omission of letter shift or figure shift. These instruments have a lighter touch than standard teleprinter keyboards, but are heavier than a normal typewriter. Verifiers were not used. The information on all forms was punched twice, each copy by a different operator, and the results were compared mechanically. Using this system it proved unnecessary to train the typists in tape code. Mistakes were erased by the typist if detected at once, or a fresh copy was made if necessary. The mechanical comparators were operated by the staff of the Computing

Laboratory, who are all accustomed to handling tape and were able to correct mistakes when detected. Blank tape was punched between the data for each student, so that the tape could be cut between them and joined as necessary. Sections containing mistakes on both tapes were sent back for repunching, whereas correct tapes were selected and joined where appropriate.

The punching took place in two phases. First the records of the students who registered in June, before going down, were punched in August and early September. There was no hurry about this part of the punching and it was carried out partly by a typist from the Registrar's office and partly by an agency typist. Records of new students and those who had not registered in June were punched during the first week of term in October, immediately after they registered. This work was carried out by three agency typists and the typist from the Registrar's office used earlier. Two thousand forms were punched in six days. It is expected that in future years the punching time will be reduced to at most four-and-a-half days, so that as punching commences at noon on the Monday of the registration period it will be finished by Friday night. The work for 1959 was scheduled to take six days, but it was brought home to us that interruptions must be adequately allowed for when estimating the time to be taken for punching, since some of the agency typists worked more quickly than others, and two had to have time off to go to the dentist during the busiest period. It was found that the copy typists from the agency could be trained to use the keyboard perforators in about half a day. By the end of the first day they were working at a moderate speed which thereafter increased with practice. It was also found that, given two accurate typists and two less accurate, it is better to pair one accurate typist with each of the less accurate ones rather than to pair the two good ones together. When the two tapes that have been punched are compared, the number of times the comparator stops on a mistake depends on the number of mistakes made by the less accurate of the two typists, but the number of times that the data has to be repunched depends on the number of mistakes the more accurate typist makes. It is considered that no time would have been saved by the use of verification equipment, which would have made it necessary to train some of the typists in tape code, and that, in the particular circumstances, the method used was preferable to that more usually used for large-scale data preparation.

Output Requirements

The lists required and the schedule for their production are now planned as follows.

1. *The Faculty Lists.* These are alphabetical lists of students under schemes of study; they show the student's name, sex, whether or not he is a new student, his date of birth, the education authority paying his grant (if any), and the subsidiary courses he is taking. An example of part of this list is given in Fig. 2. This list is duplicated and distributed by Faculties, e.g. the department of French receives a list of all students studying in the Faculty of Arts, and the Department of Physics, which teaches students from two Faculties, receives lists of students studying in the Faculty of Science and of students studying in the Faculty of Technology.
2. *The Departmental Lists.* These list students taking each subsidiary course, so informing the department providing the subsidiary course who should be attending that course and what is their parent department. These lists are sent to the department concerned, e.g. the department of Mathematics receives lists of over a thousand students who are attending courses in Mathematics and who are following main schemes of study in other departments.

B.A. SPECIAL STUDIES

LATIN

1ST YEAR

mGRAVESON BRUCE	15/ 9/40	DONCASTER	GK1.HI1.
mHORN IAN MALCOLM	16/ 6/40	BUCKS.	GK2.HI1.
m•REMINGTON TERESA EVELYN MARY	9/ 2/41	SURREY	GK2.HI1.
m•ROSENBERG MIRIAM JEAN	24/ 1/41	SOMERSET	GK2.HI1.
m•SAUNDERS BARBARA ANNE	24/ 9/40	WARWICKSHIRE	GK1.HI1.
m•WILLIAMS MADELINE DOROTHY	18/ 2/41	DENBIGHSHIRE	GK1.HI1.

2ND YEAR

•CURRY JUDITH MARY	8/ 5/40	LANCS.	GK2.HI2.
•LEACH BARBARA JOAN	9/ 8/40	STATE	GK2.HI2.
•TYSON SHEILA	8/ 5/40	ROCHDALE	GK2.HI2.

3RD YEAR

•APEW JANICE	24/ 7/40	W.R.C.C.	GK3.HI3.
•GREEN ENID CONSTANCE	3/11/38	NOTTINGHAM	GK3.HI3.
•MUNNERLEY JUNE ALICE	2/ 6/39	LANCS.	GK3.HI3.
•PEACE GERALDINE YVONNE	26/10/39	STAFFS.	GK4.HI3.
RIMMINGTON RICHARD	9/ 5/39	LINDSEY	GK3.HI3.
•STRANGE GLENDA DAWN	3/10/37	IPSWICH	GK4.HI3.
WEST JOHN	9/ 7/39	LINDSEY	GK3.HI3.

Fig. 2.—Part of a Faculty List.

Faculty and Departmental lists are first produced in the second week of September, and show all returning students proceeding normally with their course who have registered with their departments in June. The purpose of this circulation is two-fold—firstly to forewarn departments of the number of returning students to expect, and secondly to give a department providing a subsidiary course the opportunity to object to a registration made by a parent department. In such cases the record of the student concerned is withdrawn from the computer, and the student re-registers in October.

Faculty and Departmental lists are then sent out again in duplicated form immediately after registration to include all students who have registered by the end of the registration period, the added names being mainly

new students. An attempt is made to send these lists to departments before lectures start, or at least before the second lecture of a series is given.

The Faculty lists are printed out again at the end of October to include students who have registered late, and any amendments that have by then been notified to the Registrar. This version then forms the basis of the official List of Students printed for circulation within the University.

3. *Alphabetical List.* This list shows all students in alphabetical order of surnames, and gives each student's name, sex, whether or not a new student, whether studying full or part-time, faculty, type of course, whether living during term-time at home, in lodgings, or in a Hall of Residence, and scheme of study.

   This list is produced early in the second week of the October term, when Faculty and Departmental lists have been sent out. It is intended as a reference list for use in the administrative offices.

4. *A list of Overseas Students.* This list shows all overseas students registered by the end of October grouped alphabetically under their countries of origin, and gives the same information as the alphabetical list. This is of value to the Warden of Overseas Students, and information from it is sent to various bodies interested in the welfare of overseas students.

In addition, it is necessary to compile various statistics required by the Council in mid-October, by the Senate at the end of October, and by the University Grants Committee in October and the following June; these are all based on the student records extracted from the registration form.

Some Practical Difficulties encountered

It is, of course, almost impossible to be sure that every possible circumstance has been allowed for in planning mechanization. The Computing Laboratory therefore refused to guarantee the accuracy of any lists produced in 1959. It was even suggested at first that only a trial run on part of the data should be done then. However, it was judged that little extra programming would be needed to process all the data, and a thorough test of the system was attempted.

At the time of registration in October not all the programs required were fully working, and they were in fact finally completed by trying them on the actual data as it arrived. The alphabetical listing program was not even written when registration began, but as the computer program did not demand presorting of the forms, they were processed in random order within faculties, and consequently the lack of an alphabetical list soon made itself felt. Furthermore, under manual procedures, the issuing of attendance certificates, to be sent on the first day of term or very soon after to grant-awarding authorities, was linked with the registration form from which the necessary data was extracted—indeed, at that time the form was the only documentary evidence available of the presence of the student at the University. It was found that forms were required both at the punching site and in the Registrar's office simultaneously, which caused some confusion and delay. In future years these certificates will be prepared by the machine, except where local authorities demand that the certificates are given on their own proforma, and it is hoped to negotiate with these authorities to waive this requirement.

It was impossible to obtain a reliable estimate in advance of the number of corrections (one student with an address in Hong Kong alleged he was living at home and commuting during University terms) and of changes of courses affecting registrations made in June. In practice the volume was found to be considerable; they mainly concerned subsidiary courses and not the main scheme of study. During the 1959 operation, corrections were made to the lists by hand. It is hoped that the number of corrections will be less in subsequent years, but in any case a suitable program will be provided to deal with those corrections which are required.

Under the procedures actually adopted for registration, the formal registration of all students with departments at the beginning of term in October took place in less than two days. Reduction of the time necessary to carry through this part of the work revealed a weakness in the system concerned with the collection of fees from students. The arrangements for this were inadequate to deal with the speed at which the students were registered. As a result, the Bursar's office are now considering some modifications in the fees collection procedure, and a new system will be designed for use next year.

Conclusions

The work done so far has been discussed in considerable detail in the hope that the various points made will be of use not only to other University administrations wishing to apply similar techniques, but also to a wider public concerned with data processing. In carrying out some of the operations, common practice has not always been followed, notably in regard to paper tape preparation, nor have orthodox programming methods always been used for listing and sorting. The techniques used will, in fact, be discussed in a later paper.

It is realized that much of the work described could equally well have been carried out with a punched-card system, but it seemed pointless to install such a system when a computer was already available which, in the long run, would be capable of handling more complicated procedures, and which would have a far greater potential for educational research. What has been so far achieved shows that a reasonably smooth transition can be made from manual to electronic methods without going through the use of punched cards as an intermediate phase.

From the administrative point of view, while it is difficult at the outset, because of the extensive amount

of detailed work involved in setting up the new system, to make a precise estimate of its advantages, it is nevertheless already clear that mechanization of a large, centralized system of student records is worth while. The benefits may be summarized as follows.

1. Earlier preparation and distribution of lists and statistics, including the provision of services not hitherto possible.
2. Economy in clerical labour. Thus, although the data has to be punched twice for input to the computer, it is possible from this data to produce any number of lists of students in various forms and for various purposes, together with statistics relative to student numbers which formerly had taken a considerable time to prepare by hand. The use of the machine should make it possible to deal with increasing numbers of students without proportionate expansion of the staffing of administrative offices.
3. A reduction in the amount of routine work falling on academic members of staff.
4. Possibilities of short-term development. The procedures described have already produced good enough results to justify the time and trouble spent in setting up the new system, and their continuation in future years should, without much further administrative work, enable a fair return to be given for the amount of input effort involved. But there are other large-scale clerical jobs, such as the preparation of certificates of registration and attendance certificates, and the calculation of fees to be claimed from each Local Authority, which, with a very slight adjustment to the input program, could well be taken over by the computer, and which, since they would exploit existing records, would show quite substantial gains in work economy.
5. Possibilities of long-term development. Eventually it is hoped to enter into the machine fuller details of students' records, such as the results of examinations, and the consequent findings should be valuable in the consideration of matters such as the selection of students for admission to the University and the planning of University courses.

Acknowledgements

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Book Review *(concluded)*

scheme is written as a horizontal string of arithmetical and discriminatory operators, thus

$$A_1A_2A_3\ldots\ \overset{|A_n}{\underset{m}{}}\ \ldots$$

Here the operator A_n is labelled m. A jump instruction, for example, takes the form

$$P(x, N,\ \overset{N_1}{\overline{|[a_1, b_1]}};\ \ \overset{N_2}{\overline{|[a_2, b_2]}};\ldots;\ \overset{N_k}{\overline{|[a_k, b_k]}})$$

which means: jump to N_i if x lies in the interval $a_i \leqslant x \leqslant b_i$; otherwise jump to N.

The book contains a full description of the source language, the programming algorithms used, and a detailed description of the program. For an account of the system as seen through a "Western" user's eyes, the reader should refer to: *The Status of Digital Computer and Data Processing Developments in the Soviet Union.* O.N.R. Symposium, Washington, D.C., November 12, 1958.